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DESIGN AND DEVELOPMENT OF CARTESIAN CO-ORDINATE BASED 3D PRINTER

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ABSTRACT

Now a day, manufacturing of complex parts have become a major role in industries. By the use of subtractive processes, there is a lot of scrap and also the accuracy of parts is not up to the mark. So, to eliminate these problems Additive Manufacturing is used, which converts 3D CAD models into physical objects.

3D printer can produce parts layer by layer with the addition of the raw materials used by executing the NC-codes of a CAD designed model, which is controlled by a computer.

In this project work, Design and development of Cartesian co-ordinate based 3D printer is done for the manufacturing of sample parts by using Fused Deposition Modeling (FDM) process. The Fused Deposition Modeling is an advanced manufacturing process uses the thermoplastics, ABS, Poly Vinyl Alcohol (PVA), polycarbonate (PC), PLA (Poly Lactic Acid) and ULTEM 9085. PLA (Poly Lactic Acid) is used as the filament in this project for 3D printing of Mechanical parts and also the above mentioned raw filaments can be used. The parts are modeled in the CATIA V5 R20 software, and it is converted into STL (Stereo lithography) file. By using CURA software, the STL file is converted into G-codes and then it is sent to PRONTERFACE software, which is the interface software between the computer and the Cartesian coordinate based 3D printer. The PRONTERFACE software sends the instructions (i.e. G-codes) to the Cartesian coordinate based 3D printer and the required physical parts can be printed.

KEYWORDS: Additive Manufacturing, CATIA V5 R20,CURA, Design & 3D printer

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Original Article

INTRODUCTION

Introduction to AM

Three-dimensional printers allow quickly making and altering prototypes on their own, or through a company that specializes in rapid prototyping. The ability to design, produce and test products, five or 10 times faster enables designers and entrepreneurs much more creative freedom. In fact, prototyping has become the leading use of 3D printers globally, with the automobile and aerospace industries.

A method of manufacturing known as 'Additive manufacturing', due to the fact that instead of removing material to create a part, the process adds material in successive patterns to create the desired shape.

Theme of this Project Work

This project work is done for the purpose of gaining knowledge in oneself and also to impart the knowledge of Additive Manufacturing in the upcoming generations.

History

3D printing technology has evolved tremendously in the past few years, but the use of this technology started in the year 1984

1984	Invention of Steriolithography. It is the first 3D printer.
1992	3D Systems produced the first SLA machine
2002	Working 3D kidney created for an animal.
2005	Dr. Adrian Bowyer at The University of Bath found RepRap.
2008	Shapeways launches co-creation service and community which lead to a man to walk with a 3D printed leg.
2009	Organavo uses a Bio 3D printer to print the first blood vessel.
2009	MakerBot starts selling DIY 3D printer.
2011	University of Southampton engineers fly the first 3D printed Aircraft.
2011	KOR ecology unveils Urbee, a prototype 3D printed car.
2012	First 3D printed prosthetic jaw implanted.

2013 3D printers used in Household appliances and domestic purposes.

Rapid Prototyping Methods

Rapid Prototyping Technologies are classified as:

Liquid Based Rapid Prototyping Systems

1.3.3.1 Stereolithography

1.3.3.2 Solid Ground Curing

Solid Based Rapid Prototyping Systems

1.3.3.3 Laminated Object Manufacturing

1.3.3.4 Fused Deposition Modeling

Powder Based Rapid Prototyping Systems

1.3.3.5 Selective Laser Sintering

1.3.3.6 Three-Dimensional Printing

Rapid Prototyping Procedure

The Prototyping Procedure is given below:

- Any available CAD software is used for generating desired 3D CAD model and saved as STL file format.
- The 3D printer takes the STL file as input and gives sliced layers as output.

- A thin layer of model is deposited as support structure. The nozzle is moved up for depositing next layer and completes the model in the subsequent passes.
- The physical object with supports can removed from AM machine.
- The final object is brushed off.

Needs of Rapid Prototyping

- These techniques are currently being advanced further to such an extent that they can be used for low volume economical production of parts.
- It significantly cut costs as well as development times.

Fused Deposition Modeling

In this modeling, PLA wire of 0.063inch is inserted into the nozzle and nozzle is heated to 180^0C. After that, nozzle starts depositing the material on the table. Fist, it creates the support and then desired part. In this project, work nozzle moves up in the z-direction, whereas, the built table has movements in x and y direction. The general sketch of FDM machine is shown below. Some FDM machines use support spools for producing support structures. The diameter of nozzle is 0.75mm.

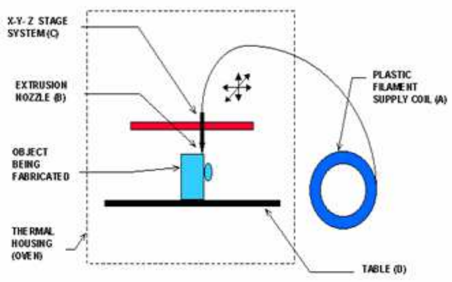

Figure 1: Fused Deposition Modeling

Advantages

- Parts manufactured layer by layer are more accurate and flexible.
- 3D printing reduces the manufacturing lead time.
- The cost of 3D printers is less, any one purchase for specific need.

Disadvantages

- This 3D printer cannot produce all types of parts.
- Higher maintenance cost and skilled operator needed.

3D PRINTER PARTS AND SOFTWARE

Technical Specification

- Printer technology : FFF
- Build base : 18*18*18 cubic centimeter

- Filament supported: 1.75mm PLA, ABS and other commonly available 3D printing material.
- Nozzle Type : Metal-Hot end
- Other features: LCD support and SD card connectivity can be made.
- Software supported: Open Source and is compatible with Windows, MAC OS and Linux.

Enabling Technologies

Building of a 3D printer necessitates the combination of software, electronics, and mechanics, see Figure for a simple breakdown of the different technologies behind a 3D printer design. This flowchart can be used to visualize how all the components connect and interact with each other to make the device work together as a unit.

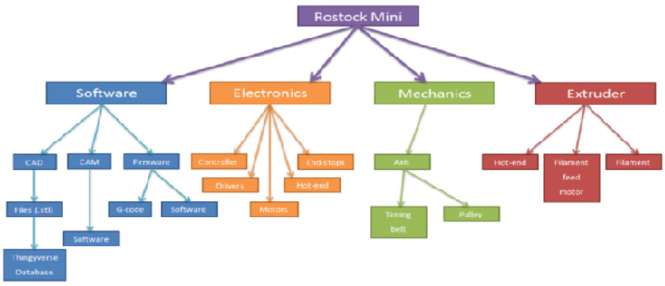

Figure 4.1: Flowchart Illustrating the Working Technologies within the Build of a 3D Printer

Basic Components to build a portable 3D printer

- Frame
- Linear bearings
- Linear motion
- Electronics
- Stepper motors
- Stepper motor Drivers
- End stops
- Extruder
- Timing Belts
- Pulleys and Fasteners

Thermoplastic Extruder

With our Cartesian system providing accurate linear positioning, we need an extruder capable of laying down thin strands of thermoplastic a type of plastic that will soften to a semi liquid state when heated. The extruder (see Figure 4.4), the most complex part of a 3D printer that is still seeing intense development, is actually the marriage of two key elements: the filament drive and the thermal hot end.

The filament drive pulls in plastic filament often, bundled in spools of either 3mm or 1.75mm diameter filament using a geared driver mechanism. Most, if not all, contemporary filament drivers use a stepper motor to better control the flow of plastic into the hot end. These motors are often geared down with printed gears or an integral gearbox, as shown in Figure 4.4, to give the filament driver the strength needed for continued extrusion.

The filament, after being pulled into the extruder by the filament driver, is then fed to the heater chamber or hot end. The hot end usually is thermally insulated from the rest of the extruder. Nozzle is made up of brass and heat block, heat brick, heat sink are made up of aluminum 6061. When the plastic reaches the hot end, it is heated to somewhere around 170°C to 220°C, depending on the plastic to be extruded. Once in a semi liquid state, the plastic is forced through a print nozzle with an opening somewhere in the vicinity of 0.35 millimeters to 0.5 millimeters in diameter.

Figure 2: Thermoplastic Extruder

Printer board

The printer board is connected to all the components and used to operate them. Which include end stops, nozzle, stepper motors, extruder etc. Also, it's the central facility that continuously monitors the temperature of the hot end of the J-head nozzle and controls the step movements of the stepper motors for the x, y and z movements of the nozzle.

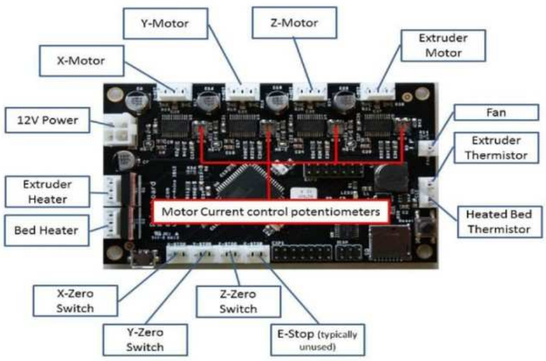

Figure 3: Aurdino Mega Printer Board Rev D

ELECTRONICS

- Stepper motors : 5x NEMA 17 (3 positioning, 1 extruder). Stepper torque ofat least 4600 g/cm.
- End stops : 3x ZM switch (pin plunger, no lever).
- Electronics : RAMPS 1.4, Arduino Mega.

- Power Supply : 12V, 10A
- Firmware : Repetier Host.
- Softwares : CURA,Pronterface.

SOFTWARE DESCRIPTION

LOAD A 3D MODEL

To prepare a 3D model for printing, you first load it into Cura for a Type of Machines by clicking the Load button near the upper left corner of the window. Curafor machines works with STL, the 3D industry standard file format, as well as OBJ, DAE, and AMF files.

The first time you open Cura for a Type Machines, a test 3D model called First PrintCone will be loaded automatically for use as your test print.

Figure 4: A CAD File Loaded Into CURA

SLICING AND SAVING 3D MODEL

After every change, you will notice a progress bar in the upper left corner. This is the slice progress. When it's done your model is ready to be sent to the printer. For large and complicated models, a slice may take a few minutes to complete.

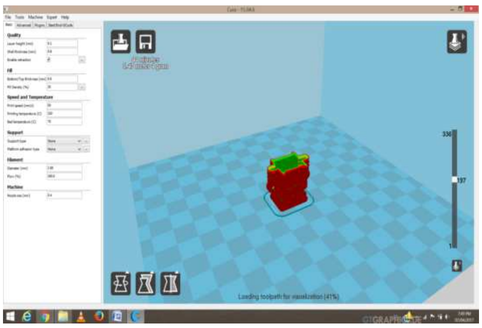

Figure 5: Slicing of 3D Model

ASSEMBLY

The assembly is the process where, all the acrylic and the electronic components of a 3D printer are joined together with the help of bolts and nuts. The assembly of parts should be done very carefully because, the acrylic frame must have a good joint, or else, the printer will not have enough accuracy at the end, while it is used.

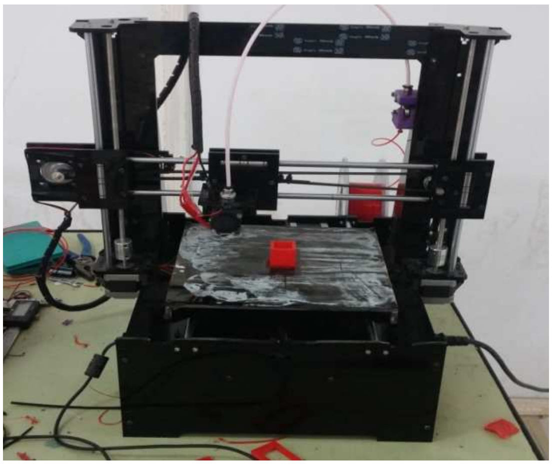

Figure 6: 3D Printer Final Assembly

CONCLUSIONS

These are the conclusions derived from the project.

- 2D and 3D models of the printer parts are designed in the Auto CAD 2010 and in CATIA V5 R20.
- Fabrication and assembly of the Cartesian Co-ordinate based 3D printer is done. The main task during the fabrication and assembly is to assemble the Acrylic frame because the frame plays the major role in the printing of parts with the specified accuracy.
- The Mechanical parts or any part to be printed is first designed in the CATIA software and CURA is used to slice the 3D CAD model into layers.
- 3D sliced Mechanical parts are printed 3D printer using PLA material with the help of interface software Pronterface.

FUTURE SCOPE

The future scope of the 3D printing is given below.

- Fully enclosed Model of 3D printer: Currently, the Cartesian co-ordinate based 3D printers are not enclosed. But, in the future there will be developments made to make the Cartesian co-ordinate based 3D printer fully enclosed.
- Build material: Acrylic is used currently in the frame build material, but in future there will be materials like fibers and other composite materials.
- Software interface: An improved GUI (graphical user interface) can be introduced in the machine which will make it easier to use and user friendly.
- 3D Scanner: As an accessory, a 3D scanner can also be used with the machine.
- Print resolution: The present resolution varies from 50 to 250 microns. Heating of print bed can also be done, in order to avoid any kind of warping of the printed layer disrupting its resolution. In the near future, the print resolution can even go less than 50 microns.

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